Sustainability

Concrete Roads Training 2021

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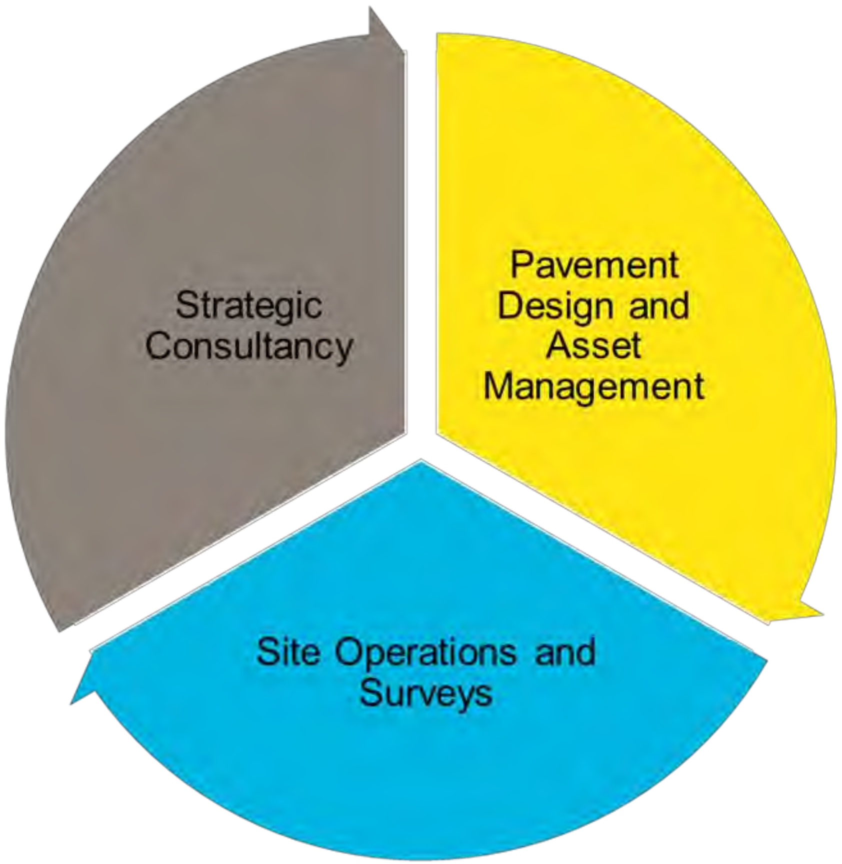
Content

AECOM Road Asset Management



- Team of over 110 staff based in the UK
- Research into practice
- Asset management and whole life cost
- Cutting edge investigation, survey and data collection techniques
- Multi skilled resource with flexibility and competencies to work cross sector
- UKAS accredited lab including pavement test facility
- Materials performance and design expertise
- One stop shop!

Recent and ongoing projects

National Highways

- Life Cycle Cost Analysis (LCCA) of surfacing material options used on the Strategic Road Network
- Concrete roads D&B (with Morgan Sindall) carbon modelling
- Collaborative research with industry partners including-
  - Developing a generic UK approach to sustainability measurement for pavement construction products and processes
  - End of product life waste/additive assessment and filtering protocol
  - Warm Mix Asphalt (WMA) Evaluation

Collaborative Research Projects

AECOM | highways england | eurobitume UK | mpa

International Projects

- Christchurch Airport GHG emissions
- NEOM

Alignment with AECOM's Sustainable Legacies

AECOM → National Highways | Common Goals

AECOM

- Reduce carbon impact by at least 50% on all major projects (Scope X)

National Highways

- Whole life carbon and net zero is a key factor in every decision
- Roads are maintained and built efficiently using very low or zero carbon solutions

Common Goals

- Use of digital tools to design out carbon and monitor emissions
- Be part of innovation in the construction sector

AECOM

- Operational Net Zero 2021 (Scope 1 and 2)
- Science-based Net Zero 2030 (including Scope 3)

National Highways

- Net zero for NH's operations by 2030 aligned with Science Based Targets
- Net zero for maintenance and construction by 2040

Common Goals

- Low carbon business culture
- 100% Renewable Energy
- Electric fleet
- Supply chain engagement
- Carbon Offsetting

AECOM

- Assessing environmental, social and governance (ESG) Risk and tracking performance
- Deliver projects that improve social value outcomes

National Highways

- Key enablers – governance, reporting, culture, partnerships and financials
- Support Government and customers to deliver zero carbon transport by 2050
- Alignment with wider environmental ambitions – air quality, biodiversity, circular economy and climate resilience

Common Goals

- Be a leader in supporting the UK's zero carbon target for 2050
- Assist in making low carbon thinking to be the norm and enable wider environmental benefits across the sector

AECOM

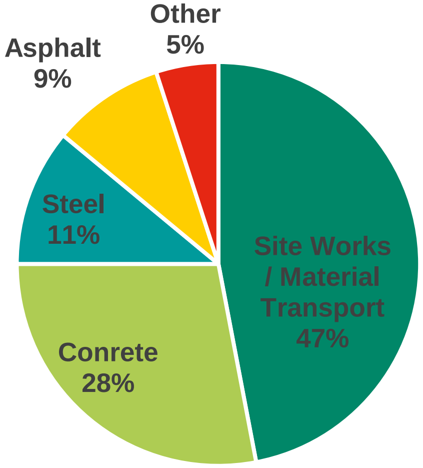
Pavement sustainability basics

Pavement sustainability- why should we care?

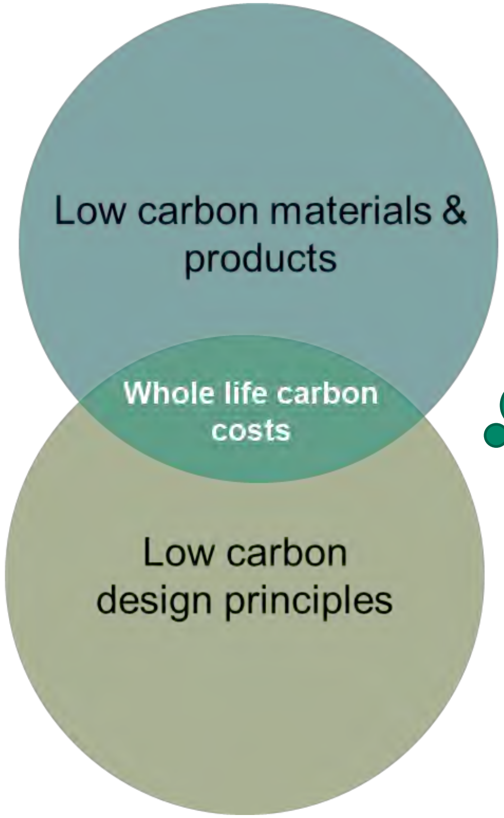
'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'

- UK Government target is to achieve net zero by 2050
- National Highways-
  - ➢ Whole life carbon and net zero is a key factor in every decision
  - ➢ Embed environmental considerations into all our activities, ranging from infrastructure design to scheme delivery
  - ➢ Net zero for maintenance and construction by 2040
- All but a handful of local authorities have declared a climate emergency
- Pavements contribute a sizeable proportion of construction related emissions

NH 2020 Maintenance and Construction Baseline Emissions Breakdown



Pavement sustainability basics



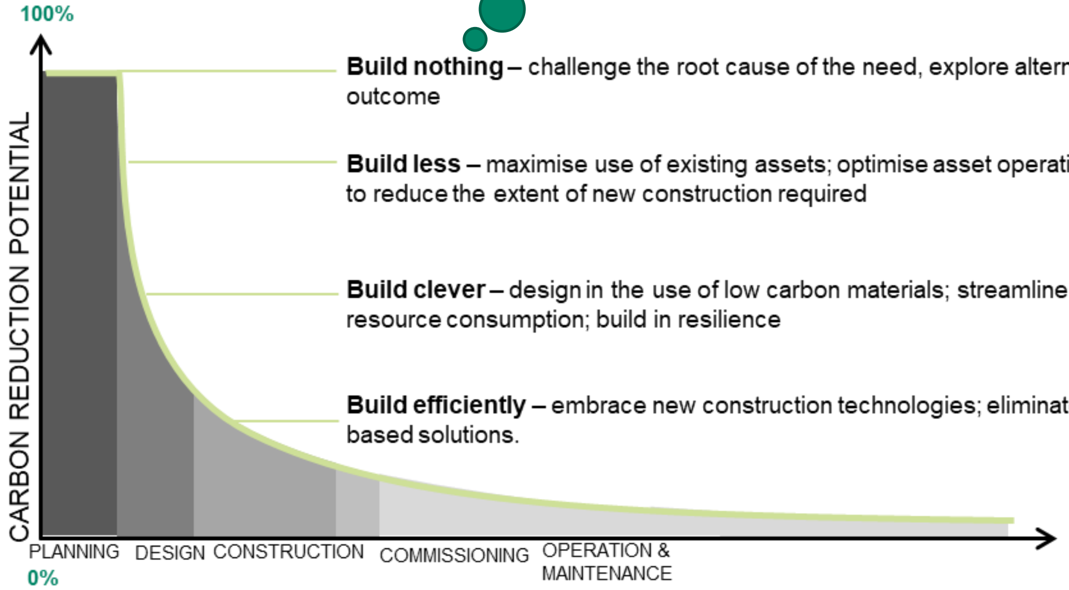
Need to think about **both** low carbon materials and low carbon design principles to create whole life carbon costs

Sooner we look at Carbon in design we can save more carbon at a lesser cost

Also need to think about the resilience of materials and products going into design

When analysing carbon reduction – we need to make sure the system isn't less resilient as a result

Some low carbon materials may not have same properties: may need to be replaced more

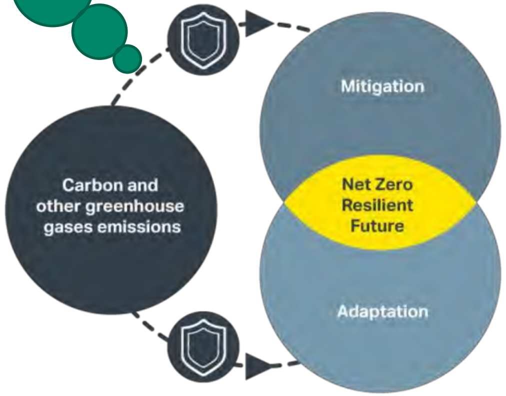


Build nothing – challenge the root cause of the need, explore alternative ways to achieve the desired outcome

Build less – maximise use of existing assets; optimise asset operation, resilience and management to reduce the extent of new construction required

Build clever – design in the use of low carbon materials; streamline delivery processes; minimise resource consumption; build in resilience

Build efficiently – embrace new construction technologies; eliminate waste; use nature-based solutions.



Pavement sustainability basics

1. ***Material Production:*** *All processes used in the acquisition (e.g., mining and crude oil extraction) and processing (e.g., refining, manufacturing and mixing) of pavement materials.*

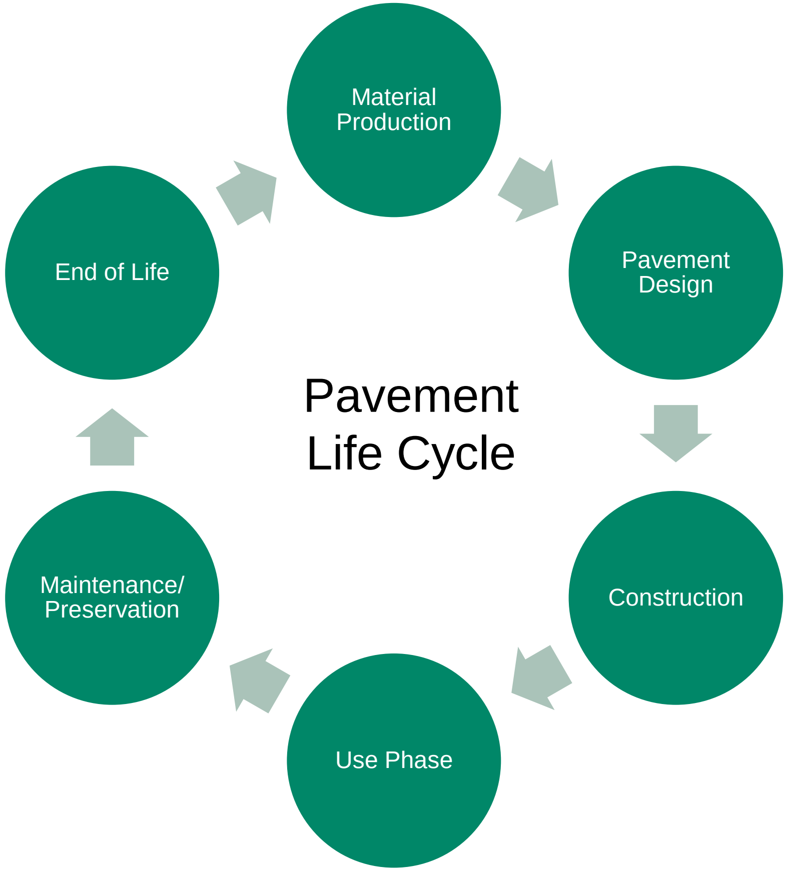
2. ***Design:*** *The process of identifying the structural and functional requirements of a pavement for given site conditions (i.e., subgrade, climate, traffic, existing pavement structure, etc.), as well as the determination of the pavement structural composition and accompanying materials.*

3. ***Construction:*** *Includes all processes and equipment associated with the construction of the initial pavement.*

4. ***Use Phase:*** *Refers to the period during which the pavement is in service and is interacting with vehicles and the environment.*

5. ***Maintenance/Preservation:*** *Activities applied at various times throughout the life of the pavement to maintain its overall serviceability.*

6. ***End of Life:*** *The final disposition and subsequent reuse, processing, or recycling of the pavement after it has reached the end of its useful life.*



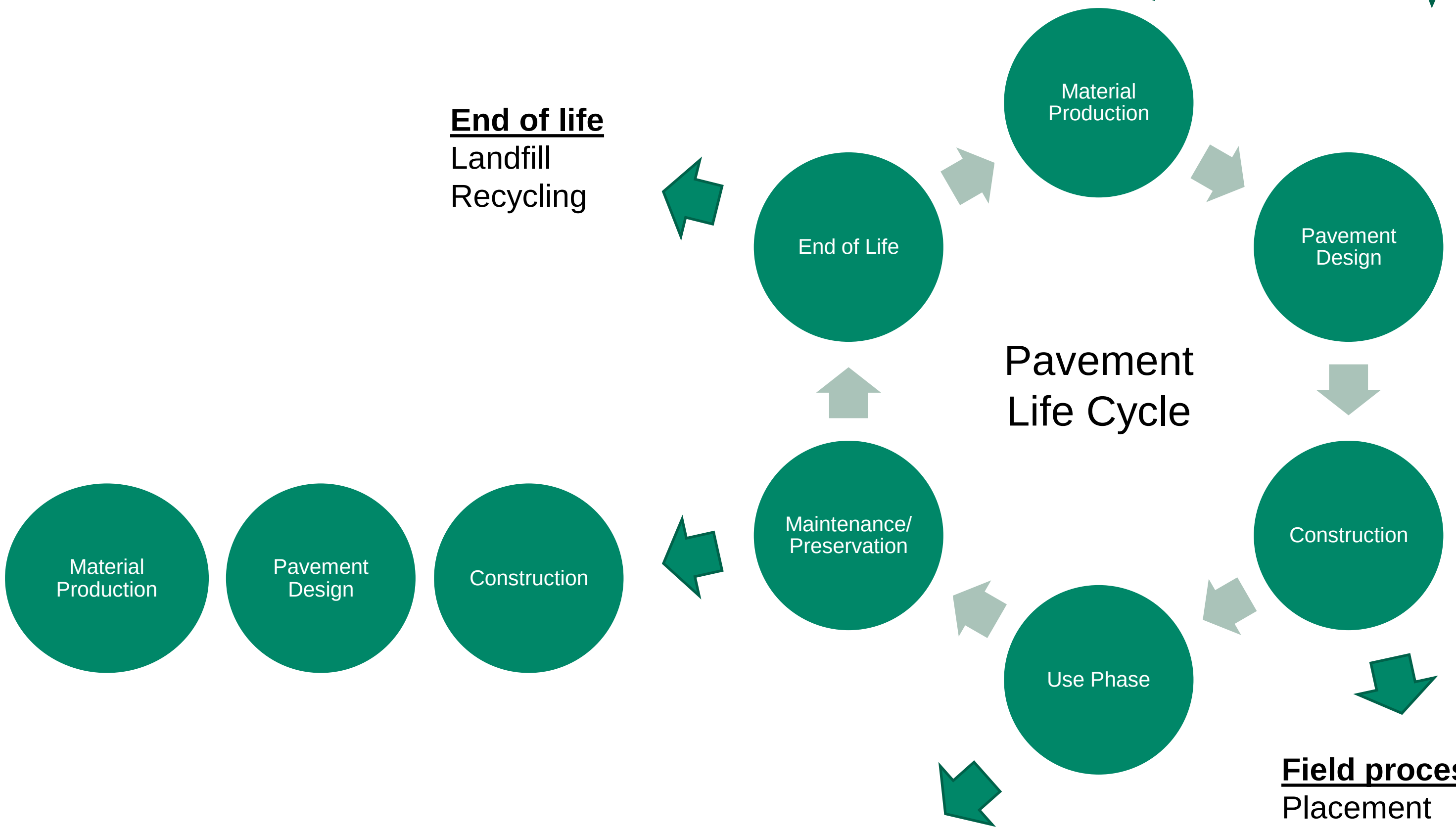
Pavement sustainability basics

Materials
Asphalt- aggregate, bitumen, filler, sand, additives, fibres
Concrete- aggregate, cement, water, admixtures, curing agent, fibres

Plant Processes
Asphalt plant
Concrete plant

Input
Fuel
Water
Equipment

End of life
Landfill
Recycling



Materials/systems considered in design
Hot mix asphalt
Warm mix asphalt
Surface treatments
Bound granular base
Unbound granular base
Subgrade
Design Traffic
Etc…

Pavement design
Surface course
Binder course
Base course
Subgrade

Use
Vehicle operation
Lighting
Congestion
Drainage
Climate change effects

Field processes
Placement
On site mixing
Rolling
Breaking
Spraying
Grinding
Milling

Input
Fuel
Water
Equipment

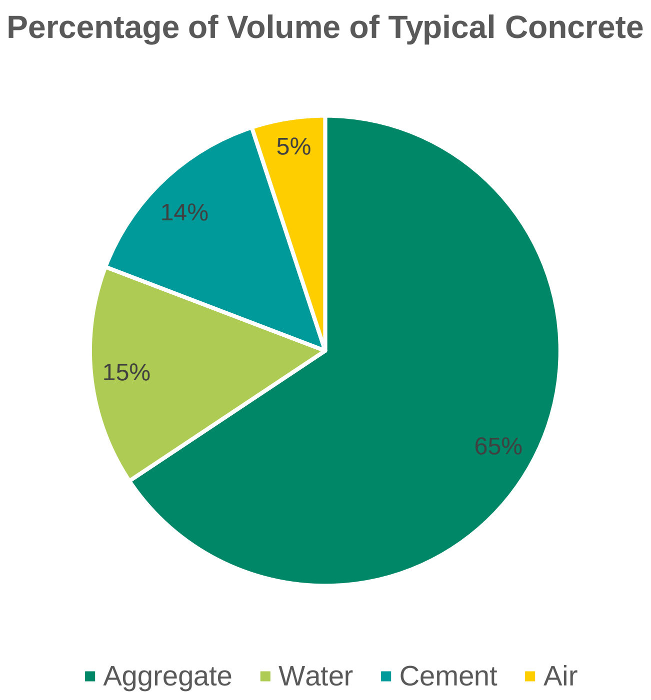
Sustainable pavement materials

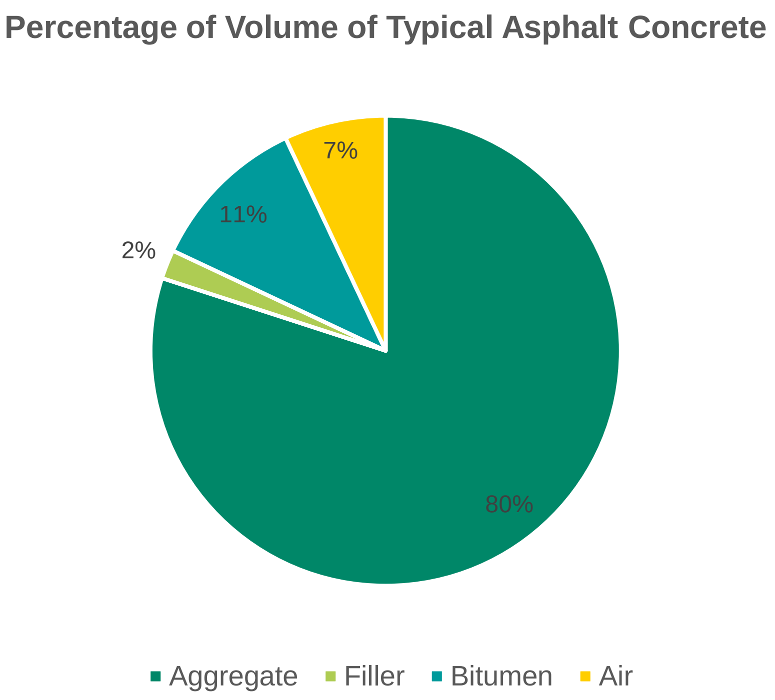
Sustainable pavement materials

- Primary pavement materials are:
  - Aggregates (virgin and recycled)- used in all asphalt and concrete pavement layers, low cost and low environmental impact
  - Bitumen- high embodied carbon value due to extraction and processing
  - Cement- high embodied carbon value to processing
  - Other (e.g. additive's, admixtures, steel for rebar)
- Sustainability considerations include:
  - Extraction, processing and transportation (gate to plant)
  - Mixture design and proportioning
  - Plant operations e.g fuel used on an asphalt plant and cement plant

Sustainable pavement materials

- Aggregate is the highest proportion by mass or volume in the material but has the lowest embodied carbon
- Cement and bitumen (Penetration Grade or Polymer Modified- PMB) have the highest embodied carbon due to very energy intensive extraction and processing
- Strategies to reduce the amount of bitumen are through recycling and in the case of cement using cement replacements e.g. Ground Granulated Blast Furnace Slag (GGBS)





Sustainable pavement materials- Aggregates

Current Aggregate Sustainability Trends

- Recycled asphalt planings (RAP)
- Recycled concrete aggregate
- Ground granulated blast furnace slag (GGBS)

Sustainability-improving strategies related to aggregates

- Use more recycled aggregates in asphalt and concrete materials
- Use more durable aggregate to maximise pavement life
- Increased used of marginal aggregates
- Demand for specialty aggregates increasing to meet specific sustainability goals

Sustainable pavement materials- Asphalt

- Many different types of asphalt materials but fall under 3 main categories: HRA, SMA, AC
- Bitumen has a large environmental impact (high embodied carbon) but only ranges from 3% to 7% of the material typically

Current Asphalt Sustainability Trends

- Increased use of warm mix asphalt technologies (now in SHW Clause 908)
- Replace virgin binder with binder from recycled asphalt planings (RAP)
- Use of ground tyre rubber
- Use of Polymer Modified Binders for increased durability

Sustainability-improving strategies related to asphalt

- **Reduce virgin binder and virgin aggregate content-** Increase RAP usage
- **Reduce Energy Use and Emissions-** Make warm mix industry standard, change fuel used for heating (e.g natural gas, Hydrogen?), increase RAP use, increase efficiency of plants
- **Extend Life of Asphalt Materials-** Improve compaction, improve mix designs, use modifiers where appropriate e.g. PMB

Sustainable pavement materials- Concrete

Many different types-

Jointed concrete- Jointed unreinforced concrete (URC) and Jointed reinforced concrete (JRC), Continuously reinforced concrete (CRCP), Roller compacted concrete

- Cement also used in subgrade stabilisation
- Cement has large environmental impact even in small volumes

Concrete Mixture Trends-

- Use of cement replacements e.g. GGBS, geopolymer activators
- Optimised aggregate gradations
- Use of alternative hydraulic cement systems (e.g., activated fly ash)

Sustainability-improving strategies related to concrete-

- **Reduce energy use and emissions in cement manufacturing-** Use renewable energy, more efficient fuels, increase plant efficiency, minimise clinker content in Portland cement, carbon capture and storage
- **Reduce energy use and emissions in concrete production-** reduce cement content in concrete mixes, use more blended cements
- **Increase use of non cementitious replacement-** e.g. GGBS, geopolymer activators
- **Improve concrete durability-** optimise water: cement ratio in mixes, quality control, increase use of supplementary cementitious materials

Sustainable design approaches

Delivering a better world

Sustainable design approaches

Design considerations related to pavement sustainability-

Performance life, smoothness/ rideability (linked to user emissions), surface friction, noise, drainage, climate, future maintenance

Sustainability Impacts from Design-

- Use of DMRB
- Pavement type selection e.g. fully flexible or composite
- Impacts every stage of the pavement life cycle
- Construction and materials selection
- Full reconstruction, overlay, inlay, maintenance
- Source/transportation of materials
- Quality of construction
- Surface performance
- Design life selection- longer life usually means lower life cycle cost and GHG emissions but often higher initial impact
- Life cycle maintenance


Design Manual for Roads and Bridges

highways england

TRANSPORT SCOTLAND

CÒMHDHAIL ALBA

Llywodraeth Cymru Welsh Government

Infrastructure

Pavement Design

CD 226

Design for new pavement construction

How to improve pavement sustainability through design

- **Achieve longer life-** high quality materials, good construction techniques/workmanship, use industry best practice e.g DMRB
- **Reduce pavement thickness-** optimise design using accurate data, use of CD226
- **Noise-** noise reducing materials
- **Achieve and maintain ride quality-** key design parameter, less interventions likely, also link to user vehicle emissions
- **Maximise use of recycled materials and local materials-** minimise transport related impacts, replace virgin materials with recycled in situ materials
- **Drainage requirements-** ensure adequate drainage

Design strategies for sustainable asphalt pavements

- Many different options- full construction, overlay, inlay, surface treatments
- Factors to consider include ground conditions, future traffic, design period, existing condition of asset
- Full depth reconstruction has the highest GHG emissions impact
  - Can reduce impact by effective thickness design (CD226) and use of high RAP content and warm mix
  - Use of stabilisation techniques to improve quality of local granular materials, however cement/lime have a high embodied carbon value
- Use of surface treatments can extend service life of the surface course material, low environmental impact
- Effective maintenance throughout the service life of the pavement will lower whole life carbon
- Appropriate material selection for the given application, use of PMB's for improved durability, use of EME to reduce pavement thickness, warm mix

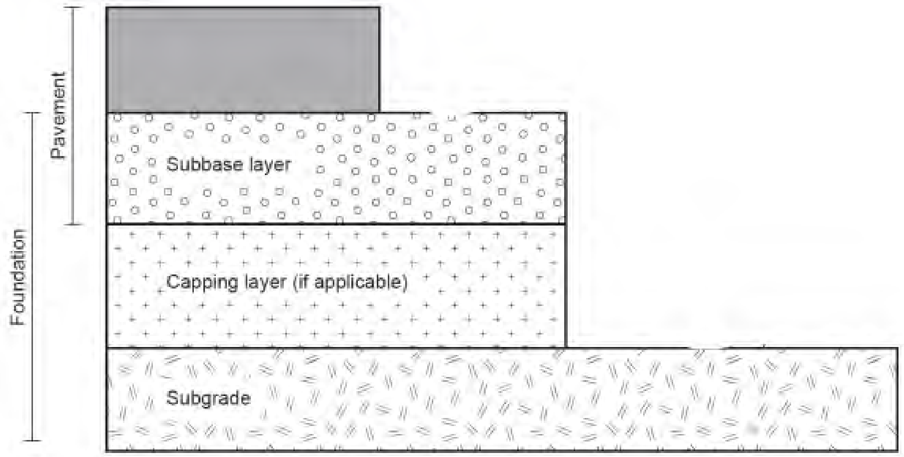
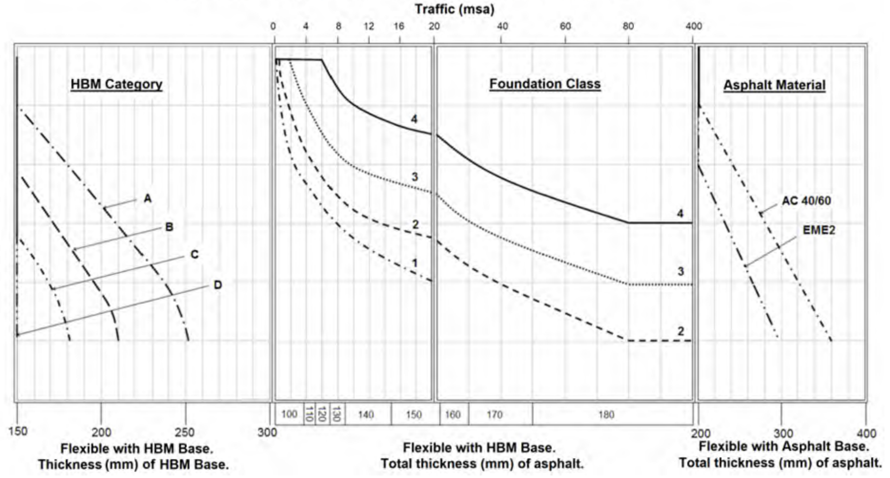
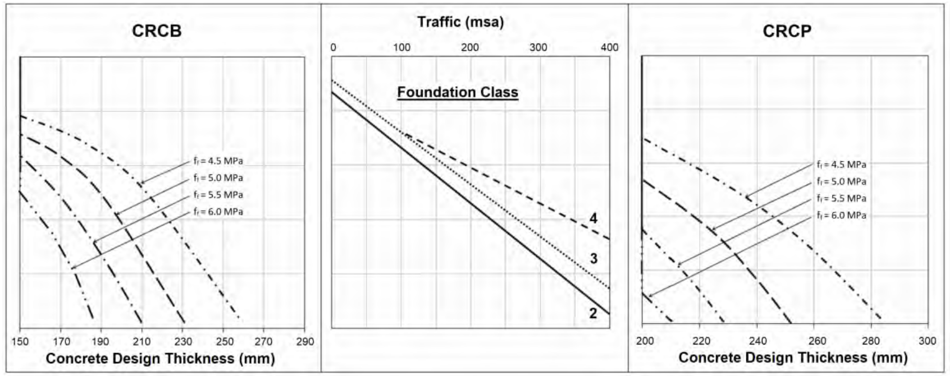


Figure 2.20 Nomograph for determining the design thickness for flexible pavements



Design strategies for sustainable concrete pavements

- Different designs- Jointed concrete- Jointed unreinforced concrete (URC) and Jointed reinforced concrete (JRC). Continuously reinforced concrete (CRCP)
- Different options- full construction, overlay, surface treatments
- Factors to consider include ground conditions, future traffic, design period, existing condition of asset
- Typically concrete pavements have a higher initial cost but lower lifecycle cost
- Effective maintenance throughout the service life of the pavement will lower whole life carbon (refer to CPMM)
- Longevity and reduced cement content provides environmental benefits
- Also potential recycling of concrete in lower layers of the pavement

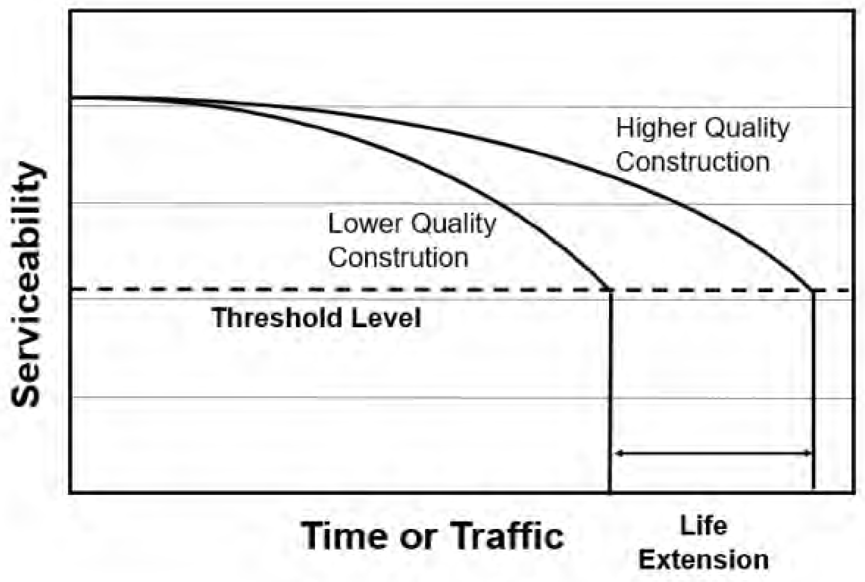


Sustainable pavement construction

Construction considerations related to pavement sustainability

Sustainability impacts through construction-

- Energy & fuel consumption
- Transport to/from site
- Construction equipment operation
- Exhaust & particulate emissions
- Traffic delays, congestion
- Noise emissions
- Pavement surface characteristics



Overall pavement performance

- Functional, structural, longevity

<u>Construction quality impacts overall pavement performance</u>

General strategies for improving pavement sustainability through construction

Use Local Materials and Low-Impact Transport- zero waste approach, reduce environmental impact of materials over the life cycle

Reduce Use of Virgin Materials- Use more recycled materials e.g RAP, use more durable aggregates to maximise pavement life, on site recycling

Initial ride quality and over service life- Pavements with good ride quality will require less interventions over its service life

Reduce energy consumption and emissions- minimise haulage distances, selection of appropriate machinery (type and size), use alternative fuels, retrofit machinery with hybrid equipment

Accelerate pavement construction- optimise working windows, construction sequencing

Sustainable construction strategies for asphalt and concrete pavements

Focus on construction quality and standards, high standard of quality will improve durability therefore less whole life carbon

Poor construction practices will compromise pavement performance

Asphalt

- Compaction
- Joints
- Ride quality
- Weather conditions whilst laying

Concrete

- Curing and finishing
- Placing reinforcement (CRCP)
- Consistency of material
- Weather conditions whilst laying

Maintenance and preservation

Maintenance and preservation basics

– Pavement preservation important as it keeps roads in good condition

– Employs maintenance, preventive maintenance, and minor rehabilitation treatments

– Typically low cost and low environmental impact

Selection of preservation techniques requires consideration of a number of different factors including-

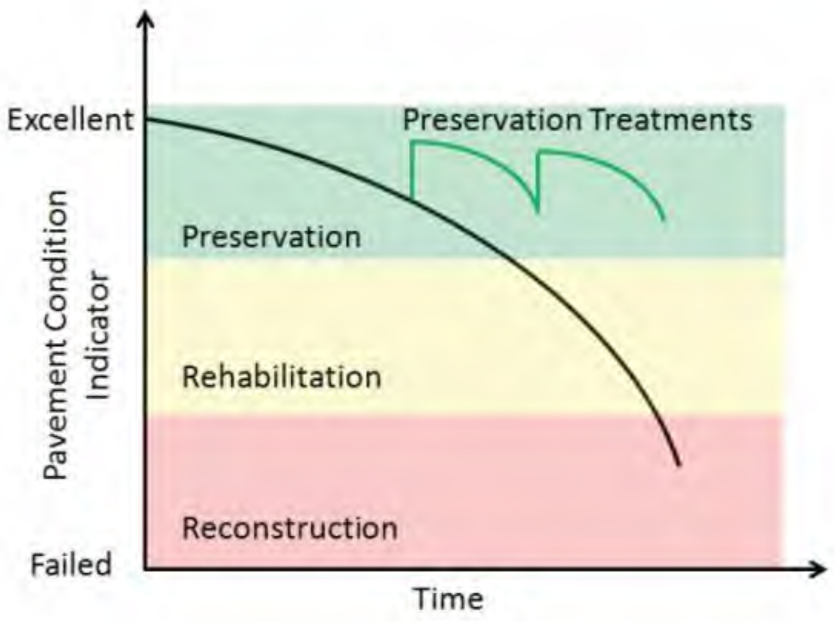
- Pavement type
- Type and extent of distress
- Climate
- Cost
- Expected life

Preservation sustainability benefits-

– Conserves energy and virgin materials

– Restores/maintains functionality

– Extends pavement life



Maintenance and preservation techniques

Asphalt

Crack filling/sealing

Patching

Rejuvenator

Microsurfacing

Surface dressing

Cold recycled bound materials

Concrete

Refer to Concrete Pavement Maintenance Manual! (CPMM)

Joint resealing/crack sealing

Partial depth repairs

Full depth repairs

Bay replacement

Thin bonded repair

Etc…

Future opportunities

- Improved treatments that last longer and require less material
- Better treatment selection
- Improved construction quality

End of life considerations

End of life options for pavements

General end of life options-

- Disposal (not the preferred option)
- Remain in place for reuse in new pavement
  - e.g. asphalt overlays
- On site and off site recycling operations
  - Reduction in fuel consumption, GHG emissions and traffic
  - Use of recycled materials without compromising on pavement performance
  - No disposal cost
  - Can be used in recycled asphalt planings (RAP) in new pavement or recycled concrete aggregate

Strategies for improving pavement sustainability-

Asphalt- higher RAP contents, use rejuvenators/softening agents, ensure good quality initial recycled product

Concrete- recycle more concrete aggregate, use in foundation layers of pavement

Questions?

Next session: Tuesday 14^{th} December 2021 12:00 – 13:00

Linear Data Visualisation (LDV)